Science Literacy, Curriculum Reform, and this Book

THE BASIC PROPOSITION OF THIS BOOK is that treating curriculum reform as a design problem will contribute significantly to the achievement of the ambitious goals of science literacy. Project 2061 takes science literacy to encompass the natural and social sciences, mathematics and statistics, technology, and their interactions. *Designs for Science Literacy* also pays attention to the need to link these science-oriented studies to the arts and humanities, to vocational education, and to other components of the total curriculum. Although the discussion of curriculum design most often is expressed in terms of that part of the curriculum relevant to science, it will likely have relevance to those other parts as well.

Designs deals with the critical issues involved in assembling sound instructional materials into a coherent K-12 whole. But it does not deal with the development of those instructional materials, and it says little about the practical problems of implementing a new curriculum design in real schools. Instead, *Designs* proposes ways to choose and configure 13 years worth of curriculum materials so that they align with established sets of learning goals, while preserving the American tradition of local responsibility for the curriculum itself.

Whether *Designs'* intent can be achieved will depend on the development of a bank of curriculum materials that have desirable built-in properties, including alignment with specific learning goals, effective styles of instruction, provisions for cognitive and cultural diversity, options for faster learners, and helpful assessment tools.

With the publication of *Designs*, Project 2061 hopes to foster more uniformity among learning goals across the nation, to simultaneously encourage more local diversity in curriculum, and to help launch effective curriculum-reform efforts.

Who Is *Designs for Science Literacy* For?

Designs has been written for five main audiences. Its purpose is to help:

- Administrators and teachers to organize curriculum change in a way consistent with a new national vision of science literacy.
- Developers and publishers of instructional materials to adopt a conceptual framework for the invention and revision of their products, concentrating seriously on the specific learning goals to be achieved.
- Designers of K-12 curricula to consider the science, mathematics, and technology components of the curriculum as a coherent whole.

- Education reform leaders to introduce near-term improvements that will contribute to significant long-term curriculum change.
- College faculty to teach the principles of curriculum analysis and design to new and experienced teachers.

Why Is Curriculum Reform Needed?

Designs presupposes that curriculum reform must be considerably more fundamental and extensive than the tinkering with individual courses and subjects that has been going on for decades. Actually, the call for broad changes in the curriculum has been made over and over again during much of the 20th century. It has reflected certain persistent criticisms of the traditional school curriculum:

> The content of the curriculum is not appropriate for meeting the individual and social needs of people living in the modern world. Simply put, the content is obsolescent. Much of what is taught is not needed in everyday life, and much of what is *not* taught *is* needed in everyday life.

> The curriculum is a mishmash of topics that lacks coherence across subject-matter domains and grade levels. It is some of this and some of that, with each piece being justified on its own without reference to a conceptual whole.

The curriculum has become grossly overstuffed with topics. The one change that seems easiest to make in a curriculum is to add something to it. So the curriculum's content grows inexorably—often in response to the public demand that schools address social problems, such as alcohol and drug abuse, AIDS, and hazardous driving. New topics are introduced but few disappear. Shallowness is one consequence, incoherence another.

The curriculum does not serve all students equally well. The problem is exacerbated by other factors, such as the inequitable distribution of educational resources and the low expectations held for some categories of students. Rarely is an existing curriculum sensitive or flexible enough to meet the needs of diverse students.

Above all, the curriculum does not produce the learning expected of it. Students may take algebra, history, biology, and the other "right" courses and do well in the course examinations, but extensive research shows they really understand and retain very little of the content. Moreover, development of curriculum and instruction typically takes too little notice of the research on what, how, and when students can learn, depending rather on tradition for topics, methods, and grade-level placement.

Though inadequate teaching plays a part in all of these problems, much of the blame can be laid at the door of the curriculum itself. (Witness the still-to-be-found travesties of trying to teach causes of the seasons in the 2nd grade or electron shells in the 4th grade.)

Designs makes a number of recommendations having to do with unburdening the curriculum. Care must be taken not to interpret these as a call for “watering down.” Far from watering down the curriculum, a concentration on understanding key ideas well will enable students to achieve higher standards than those reached by most of the students apparently “doing well” with the current curriculum. The real watering down is quite evident now in classrooms where students receive shallow instruction on so many topics that they retain nothing but a jumble of poorly understood fragments of information.

The Stubbornness of Curriculum

If these long-standing criticisms are valid, why hasn’t the curriculum been changed? In spite of many reform attempts, the 20th century has ended with pretty much the same curriculum it began with, plus a heavy sprinkling of new topics. Resistance to change is commonplace in all social systems and institutions, whether they be sports organizations, government agencies, business enterprises, or school districts. Comfort with what is familiar and anxiety about the untried lead teachers, administrators, school boards, state legislators, parents, citizens in general, and even students to be unenthusiastic about curriculum change. For instance, although polls show that parents give low marks to the nation's schools and teachers and support the idea of education reform, they also show that those same parents feel their own schools and teachers are doing well the way they are and do not need a major overhaul.

There is more to the persistence of curriculum than a mistrust of change. A K-12 curriculum is a complex structure that does not stand alone but is an integral part of an even more complex educational and social system, and therefore not easily or simply dealt with. In the United States, the power and resources needed to effect change are widely dispersed, and society is not of a single mind as to what part of the system needs changing or what direction that change should take. As Decker Walker observed in his 1990 book *Fundamentals of Curriculum*, "That the American curriculum influence system can work at all seems improbable, it is so complicated, irrational, disjointed, open, and unpredictable….The entire process can be thought of as a way for the contending parties who share authority for curriculum decisions to negotiate their differences. The parties to the negotiations are the many interested individuals and agencies…playing official, quasi-official, or unofficial roles in the curriculum influence system." What is more, the schooling experiences of both teachers and parents are likely to have been in the traditional curriculum.

Another reason for the staying power of the present curriculum is the lack of obvious alternatives to it. There are a few options for alternative teaching materials and techniques within any given course, but that is about the extent of change usually considered practical.

It is also not clear who will be responsible for designing new curricula: teachers lack the time and resources to do more than make marginal alterations in their own classes, and, in any case, are not trained to be curriculum designers. University faculties in the sciences, for their part, have limited knowledge of how young students respond to subject matter and very few have had experience drafting curriculum for the K-12 grades. Outsiders lack the authority or power to impose change on reluctant school systems.

Bringing about significant and lasting curricular change in the face of this complexity and experience is at best a decades-long undertaking, in spite of the demand by advocates of reform that changes be made in a hurry. If fundamental curriculum improvement is ever to occur, a new process for creating alternatives will have to be developed. *Designs* suggests one such process.

Why Design?

Curriculum is already rich in design: design of lesson plans, design of instructional materials, design of courses, design of course sequences. For the most part, however, these design activities are piecemeal and isolated, seldom greater in scale than a year or two of the curriculum. In other areas of human endeavor (for example, airplane manufacturing, agricultural distribution, or military operations), the design of whole systems has had great benefits—parts work better together, redundancies and gaps are reduced, and less redesign and adjustment are needed.

Fortunately, there are some general principles of how such designing is done effectively. In the belief that general principles of design can have a significant payoff for the quality of the K-12 curriculum as a whole, *Designs for Science Literacy* sketches some design possibilities and calls for practitioners to help fill in the sketch.

Organization of *Designs for Science Literacy*

The Prologue examines some of the basic principles that are useful in almost all forms of design. The eight chapters that follow it are arranged into three parts. Part I, Design and the Curriculum, considers the application of general design principles to curriculum (CHAPTER 1: CURRICULUM DESIGN), and then considers features of curriculum that are most important to design (CHAPTER 2: CURRICULUM SPECIFICATIONS).

Part II, Designing Tomorrow's Curriculum, envisions how curriculum could eventually be designed by selecting from a large pool of high-quality instructional blocks (CHAPTER 3: DESIGN BY ASSEMBLY), describes the desired characteristics of blocks and guidelines for their selection (CHAPTER 4: CURRICULUM BLOCKS), and then imagines what the curriculum-design enterprise in the future may be like for three different school districts (CHAPTER 5: HOW IT COULD BE).

Part III, Improving Today's Curriculum, suggests steps that can be taken to improve an existing curriculum and in the process prepare for its eventual transformation by implementing coherent programs of professional development (CHAPTER 6: BUILDING PROFESSIONAL CAPABILITY), emphasizing understanding of the most important ideas in the currently overstuffed and shallow curriculum (CHAPTER 7: UNBURDENING THE CURRICULUM), and enhancing the connectedness across subjects and grades (CHAPTER 8: INCREASING CURRICULUM COHERENCE). In the Introduction to Part III, there is an extended passage on practical suggestions for approaching reform, which has relevance for Part II as well.

Designs does not include references to school districts that have made recent progress in redesigning curricula. There are educators who are already doing one part or another of what is proposed, but the design process as a whole is not likely to be found anywhere. Nonetheless, it is only through practitioners—teachers, administrators, materials developers, and curriculum specialists—that the ideas in *Designs* can make sense and lead anywhere. With their help, their experiences can be built into revisions of *Designs* and into future Project 2061 tools for educational reform.

The Epilogue offers another look at *Designs for Science Literacy* and reviews some of the main (and potentially controversial) propositions in the book and attempts to clarify and/or defend them.

Inside the back cover of this book is *Designs on Disk*, a companion CD-ROM. *Designs on Disk* includes a collection of databases, background readings, and utilities to help educators take on many of the curriculum design tasks recommended here. Throughout the book, marginal notes refer the reader to relevant components on the CD-ROM.

The Project 2061 Tool Kit for Education Reform

The curriculum is only one part of a complex education system, and reforming it alone will not suffice to ensure that students achieve science literacy. In the absence of corresponding changes in teacher education, state and local education policies, teaching resources, assessment, administrative practices, and so on, it is unlikely that the curriculum can be changed significantly.

Designs for Science Literacy is meant to be part of a coordinated set of tools that educators can use to improve teaching and learning in science, mathematics, and technology. These tools have been developed as a result of the project's efforts to help reform K-12 education nationwide so that all high-school graduates are science literate. From the start, Project 2061 has defined science literacy broadly to include knowledge and skills in science, technology, and mathematics, along with scientific habits of mind and an understanding of the nature of science and its impact on individuals and its role in society.

Working with panels of scientists, mathematicians, and technologists, Project 2061 set out in 1985 to identify the knowledge and skills that would constitute adult literacy in five subject areas: biological and health sciences; mathematics; physical and information sciences and engineering; social and behavioral sciences; and technology. These learning goals were eventually integrated into the project's landmark document, *Science for All Americans* (1989), which outlines what all students should know and be able to do in science, mathematics, and technology after 13 years of schooling.

In 1993, Project 2061 collaborated with teams of teachers from six carefully selected school districts to create *Benchmarks for Science Literacy*, a curriculum design tool that translates the literacy goals of *Science for All Americans* into expectations of what students should know at the ends of grades 2, 5, 8, and 12. Both documents have had a major impact on education, providing the foundation for national science education standards and helping to shape curriculum frameworks and standards in numerous states and school districts.

Project 2061's tool kit now includes a variety of books, CD-ROMs, and on-line tools to help educators make significant improvements throughout the system:

- *Resources for Science Literacy: Professional Development* (1997) provides educators with valuable background materials to improve their own knowledge and skills.
- *Blueprints for Reform* (1998) outlines changes needed in a dozen areas of the education system to improve learning in science, mathematics, and technology.
- *Dialogue on Early Childhood Science, Mathematics, and Technology Education* (1999) discusses the latest findings on teaching these subjects to preschool children.
- *Middle Grades Mathematics Textbooks: A Benchmarks-Based Evaluation* (2000) and *Middle Grades Science Textbooks: A Benchmarks-Based Evaluation* (2000) present the results of Project 2061's analysis of both widely used and newly developed middle school mathematics and science texts. Similar evaluations of high school algebra and biology textbooks are under way.
- *Resources for Science Literacy: Curriculum Materials Evaluation* (2000) reports on Project 2061's approach to analyzing and evaluating instructional materials.
- *Atlas for Science Literacy* (2000) maps out connections among benchmarks to show how student learning progresses over time and how content connects across disciplines.

Eventually these tools and other resources will be merged into a comprehensive, easily accessible on-line system.

Designs is intent upon exploring future possibilities, not about finding immediate solutions to all of our curriculum problems. In that spirit, it is more important that you enter into the conversation than that you agree with what is presented here.